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THE USE OF TOPOGRAPHIC MAPS IN HIGHWAY LOCATION

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THE USE OF TOPOGRAPHIC MAPS IN HIGHWAY LOCATION

C. P. Owens¹

Topographic maps have always been a valuable aid to the highway locating and planning engineer. As traffic has increased in volume, weight and speed we have seen the demand grow for straighter, wider, better and safer highways. The higher the standards of the highway the greater the need for topographic maps for highway location, design and economic studies. The development of the expressway or freeway type of highway has created an entirely new concept of highway location.

In the beginning of state highway building in Missouri, which was in the early 20's, good maps were not available. There were no county maps showing roads or drainage. There were a few county soil maps available in some of the agricultural counties. There were a few Geological Survey quadrangle sheets, but these had been made for reconnaissance purposes and were generally of a small scale, usually with 50-foot contour intervals, and were not reliable for the uses we now have for modern maps.

Fortunately the Centennial Road Law, in setting up a bipartisan highway commission of four members, also included the state geologist as a fifth member ex-officio. The state geologist at that time was the late Dr. H. R. Buehler, who has since been succeeded in office by Dr. Edward L. Clark. The state geologist directs the Geological Survey work in Missouri. State funds for matching federal funds were limited but since the highway engineers soon saw the need for better and more complete coverage of topographic maps, the State Highway Commission has contributed substantial sums annually in order to expand the work of completing quadrangle sheets throughout Missouri. As a result Missouri is well advanced, having approximately 68% standard topographic map coverage.

The work is continuing as fast as funds will permit. The Geological Survey and the state highway department engineers work closely in planning mapping programs for the future needs. Unsurveyed areas are rapidly being filled in with newer, more usable maps of a scale 1 to 24,000 with contour intervals of 5 or 10 feet. Older maps of smaller scales and made by the slower, less accurate ground methods are being replaced by the more usable, more accurate stereoscopic photogrammetric methods.

During the past twenty years the Geological Survey has used photogrammetric methods and is producing excellent maps now so valuable to the highway locating, planning and design engineers. These maps are almost indispensable in locating, planning and designing the modern highway and express highway systems.

Through the fine cooperation of the state geologist, an ex-officio member of the State Highway Commission, and the U. S. Geological Survey office at Rolla, Missouri, the state highway engineers are furnished advance sheets and even copies of worksheets which are to a scale ideal for preliminary location studies.

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Although the available topographic quadrangle sheets may be of different scales or to scales sometimes not suitable for engineering use, it is no particular trouble to reproduce them to a common scale and to a scale that is more usable by engineers.

The reproduction department of the Missouri State Highway Department has become quite skilled in blowing up quadrangle sheets of varying scales to a common scale. Usually our photostat reproductions are made to a scale of 1,000 feet to 1 inch and on a thin paper which permits reproductions in blue-print or black line copies. If the photostat process is carefully used it is surprising how well one sheet matches another, even when reproduced from different scales. These photostat prints may be joined together to make a continuous strip along any desired highway location.

These reproduced strips of topographic maps, together with available aerial pictures and our up-to-date county maps showing all highways, railroads, cities, towns, and rural units such as farm homes, schools, churches, cemeteries, etc., comprise the basic data used in making studies of new highway locations.

The first step in making a highway location is the determination of the type of highway to be located between designated points. First, it is necessary to determine the volume of traffic to be served now and in the future. Past and present traffic records are reviewed. Population served is a factor, together with the rate of growth of population, past and future. Induced traffic, or traffic that is attracted by the type of improvement proposed, is also a factor. All these factors and their effect on the future volume and kind of traffic that will use the new highway facility must be carefully considered, but the procedure cannot be covered here as traffic studies are a separate and complete subject foreign to this discussion except they must be mentioned here in connection with the use of topographic maps.

The volume of traffic to be served by the new highway improvement determines the standards of alignment, curvature, directness of route, grades, width of roadway, width of right of way, control of access, etc., to be used in determining the new highway location. Traffic studies may indicate a two-lane high type highway might be adequate for the present; however, traffic studies projected into the future may indicate the ultimate need for a four-lane divided highway. In this latter case the initial project would be for two-lane highway constructed on a right of way wide enough to accommodate additional lanes at a later date.

After the standards for the new highway are determined, topographic maps are used to study possible locations. Paper locations are made on which the proposed alignment is projected and profiles are scaled and plotted. Grades are determined, and from the contours, crossroad intersections are planned either at grade or for separation. Through the use of these contour maps it is convenient to determine if and how side and crossroads might be relocated to fit the revised plan. Preliminary strip maps showing alignment, profile and grades are prepared from these paper locations on topographic maps. Finally, and following careful field inspection, engineering reports are prepared showing the basic information and conclusion. These reports include construction and right of way estimates which have been made possible by the use of topographic maps.

In case there are alternate locations careful comparisons are made of each alternate line. It is even possible to make economic studies from the traffic users' standpoint. It is quite possible to scale the difference in travel distance and from the profiles determine the difference in grade, length of grades,

difference in curvature, etc., that would affect motor vehicle operating costs. Highways carrying heavy volumes of traffic must be carefully located if the highway user is to benefit from shorter distance, improved grades, better curvature, freedom of movement, and time saved. Often highway user benefits will justify in only a few years' operation substantial differences in right of way and construction costs of one route as compared with another.

Thus from a brief review of basic highway location problems are we able to emphasize the value of topographic maps to the highway engineer. They not only save his time, but without adequate contour maps it would be virtually impossible for him to make the most desirable location and to make comparative construction and economic studies without doing a vast amount of expensive field survey work.

Topographic maps are also invaluable for drainage and hydraulic studies and design. Drainage areas, both large and small, together with runoff characteristics, are obtainable from topographic maps. The higher the type of highway the more important is drainage. On expressways, especially in urban areas, storm drainage is often a major item of expense. Storm sewers needed to handle intercepted drainage as well as water from the facility itself are often a major and expensive item of cost. They must be carefully and economically, but adequately, designed. Contour maps are essential for the sound determination of these facts.

Since World War II there has been a rapid growth and development of aerial surveys and the use of photogrammetry not only for highway location but also for the actual preparation of highway plans. Aerial mapping for stereoscopic study, aerial mosaics and accurate contour maps from aerial photographs are being used more and more to replace ground survey parties. In heavily built-up areas or in rough terrain photogrammetry is how almost indispensable to the highway engineer. This is especially true in rapidly developing urban areas where often the real estate developer has run away from the map maker. Aerial survey methods are often necessary to keep up with the rapid urban development.

Only recently has Missouri undertaken aerial surveys by commercial firms on a scale that would permit actual plan preparation by such methods. On one particular portion of the Interstate System that traverses a rather rugged section of Missouri but which is partly thickly settled and built up commercially, we have attempted the use of photogrammetric methods of preparing highway plans. Our first step was to use the available Geological Survey maps, some of which were rather old and obsolete. These were expanded to a scale of 1000 feet to the inch by means of photostat methods. Strip maps were prepared of these topographic strips. Engineers were assigned to study possible locations utilizing these topographic strip maps and aerial photographs obtained from the Agricultural administration, together with field investigations. By these methods a general location was selected. In some cases, alternate locations were indicated.

Firms engaged in aerial photogrammetric work were called in and asked to submit proposals for flying aerial strips. We requested work that would first give us contact prints on the scale of 500 feet to the inch, suitable for stereopticon study. We also asked for mosaic strips on a scale of 200 feet to the inch and approximately four feet in length. Upon receipt of this information we studied further our initial location and indicated an approximate center line around which contours were to be furnished at the scale of 100 feet to the inch and with contour intervals of 2 feet. The contour strips were to be 800 feet either side of the indicated center line, or an over-all width of 1600 feet.

Upon receipt of this information the highway engineers will proceed to more definitely locate the final center line of the proposed highway. When this center line is located, a survey party will be put into the field to run that center line and its profile plus cross sections at critical points such as culvert locations, crossroads intersected, and at bridge sites, etc. The center line profile will also be used to check the guaranteed accuracy of the maps.

Generally, our aerial survey contracts the following tolerances:

Vertical tolerance: for 90% of the area included, contours shall be within $1/2$ contour interval and for not to exceed 10% of the area, contours shall be within one contour interval.

Horizontal tolerance: for 90% of area included, objects shall be located within $1/40$ of an inch of actual position; and, for not to exceed 10% of area, objects shall be located within $1/20$ of an inch of actual position.

Following the location of the center line and aerial contractor will then furnish us with standard plan-profile sheets with the ground topography plotted from photogrammetric methods.

It will be the plan to scale cross sections used for grading purposes from the 2-foot contour maps but with the general conformity of the cross section corrected to actual ground elevation as determined from ground survey profile readings.

By this method we hope to utilize aerial methods for first locating the highway since in one aerial flight a strip some 4,500 feet in width is photographed. The center two-thirds, or about 3000 feet wide, is usable for contour work is necessary, but generally we believe our center line will lie within the middle third of the picture, due to the results obtained by initial use of standard quadrangle maps.

By following this method we have reduced the cost of aerial surveys to the minimum; first, by the use of available topographic maps; and second, by confining the aerial work to one trip over the area. The amount of the contour work is reduced to the minimum by carefully locating our center line from the aerial mosaics and restricting the contour work to that actually needed. Ground survey work has been reduced to the minimum since the photogrammetric scales are sufficient to permit plan preparation according to standard procedure.

In another project on a sizable urban project we had used available contour maps of 5-foot interval, scale 200 feet to the inch, to locate our center line fairly accurately. Aerial photographs plus city plats showing lot lines, assessed valuations, etc., were used to make preliminary studies in sufficient detail to enable us to locate the center line and the scope of our improvement fairly accurately. The problem was how to go into this built-up area and survey around, between and over numerous houses, stores, buildings, etc. It was decided to use aerial photogrammetric methods, under which we expect to obtain accurate topographic maps showing all street intersections with ground topography on a scale of 50 feet to the inch. Contours will be furnished on 1-foot intervals. We expect to do a certain amount of ground survey work in order to tie in adjacent street intersections at critical points in our final design. Otherwise, we hope to use these aerial maps for the completion of our design of this proposed expressway project.

We have not advanced far enough as yet to draw any conclusions, except to say that we are sold on the process and the methods outlined and we do not expect to be disappointed.

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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c. Discussion of several papers, grouped by Divisions.

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